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National Occupational Analysis

2010 | Tool and Die Maker

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Canada

Occupational Analyses Series

Tool and Die Maker

2010

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Trades and Apprenticeship Division
Workplace Partnership Directorate
Human Resources and Skills Development Canada
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Gatineau, Quebec K1A 0J9

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FOREWORD

The Canadian Council of Directors of Apprenticeship (CCDA) recognizes this National Occupational Analysis as the national standard for the occupation of Tool and Die Maker.

Background

The first National Conference on Apprenticeship in Trades and Industries, held in Ottawa in 1952, recommended that the federal government be requested to cooperate with provincial and territorial apprenticeship committees and officials in preparing analyses of a number of skilled occupations. To this end, Human Resources and Skills Development Canada sponsors a program, under the guidance of the CCDA, to develop a series of National Occupational Analyses (NOAs).

The NOAs have the following objectives:

- to describe and group the tasks performed by skilled workers;
- to identify which tasks are performed in every province and territory;
- to develop instruments for use in the preparation of Interprovincial Red Seal Examinations and curricula for training leading to the certification of skilled workers;
- to facilitate the mobility of apprentices and skilled workers in Canada; and,
- to supply employers, employees, associations, industries, training institutions and governments with analyses of occupations.

ACKNOWLEDGEMENTS

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This analysis was prepared by the Workplace Partnerships Directorate of HRSDC. The coordinating, facilitating and processing of this analysis were undertaken by employees of the NOA development team of the Trades and Apprenticeship Division. Leah Tussman for the host jurisdiction of Ontario also participated in the development of this NOA.

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LIST OF PUBLISHED NATIONAL OCCUPATIONAL ANALYSES (Red Seal Trades)

TITLE	NOC* Code
Agricultural Equipment Technician (2007)	7312
Appliance Service Technician (2005)	7332
Automotive Painter (2009)	7322
Automotive Service Technician (2009)	7321
Baker (2006)	6252
Boilermaker (2008)	7262
Bricklayer (2007)	7281
Cabinetmaker (2007)	7272
Carpenter (2010)	7271
Concrete Finisher (2006)	7282
Construction Craft Worker (2009)	7611
Construction Electrician (2008)	7241
Cook (2008)	6242
Electrical Rewind Mechanic (1999)	7333
Electronics Technician – Consumer Products (1997)	2242
Floorcovering Installer (2005)	7295
Glazier (2008)	7292
Hairstylist (2009)	6271
Heavy Duty Equipment Technician (2009)	7312
Industrial Electrician (2008)	7242
Industrial Mechanic (Millwright) (2009)	7311
Instrumentation and Control Technician (2010)	2243
Insulator (Heat and Frost) (2007)	7293
Ironworker (Generalist) (2010)	7264
Ironworker (Reinforcing) (2010)	7264
Ironworker (Structural/Ornamental) (2010)	7264
Landscape Horticulturist (2010)	2225

*National Occupational Classification

TITLE	NOC* Code
Lather (Interior Systems Mechanic) (2007)	7284
Machinist (2010)	7231
Metal Fabricator (Fitter) (2008)	7263
Mobile Crane Operator (2009)	7371
Motorcycle Mechanic (2006)	7334
Motor Vehicle Body Repairer (Metal and Paint) (2010)	7322
Oil Heat Systems Technician (2006)	7331
Painter and Decorator (2007)	7294
Partsperson (2010)	1472
Plumber (2010)	7251
Powerline Technician (2009)	7244
Recreation Vehicle Service Technician (2006)	7383
Refrigeration and Air Conditioning Mechanic (2009)	7313
Rig Technician (2008)	8232
Roofer (2006)	7291
Sheet Metal Worker (2010)	7261
Sprinkler System Installer (2009)	7252
Steamfitter — Pipefitter (2010)	7252
Tilesetter (2010)	7283
Tool and Die Maker (2010)	7232
Transport Trailer Technician (2008)	7321
Truck and Transport Mechanic (2010)	7321
Welder (2009)	7265

Requests for printed copies of National Occupational Analyses may be forwarded to:

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Workplace Partnership Directorate
Human Resources and Skills Development Canada
140 Promenade du Portage, Phase IV, 5th Floor
Gatineau, Quebec K1A 0J9

These publications can be ordered or downloaded online at: www.red-seal.ca. Links to Essential Skills Profiles for some of these trades are also available on this website.

STRUCTURE OF ANALYSIS

To facilitate understanding of the occupation, the work performed by tradespersons is divided into the following categories:

Blocks	the largest division within the analysis that is comprised of a distinct set of trade activities
Tasks	distinct actions that describe the activities within a block
Sub-Tasks	distinct actions that describe the activities within a task
Key Competencies	activities that a person should be able to do in order to be called 'competent' in the trade

The analysis also provides the following information:

Context	information to clarify the intent and meaning of tasks
Trends	changes identified that impact or will impact the trade including work practices, technological advances, and new materials and equipment
Related Components	a list of products, items, materials and other elements relevant to the block
Tools and Equipment	categories of tools and equipment used to perform all tasks in the block; these tools and equipment are listed in Appendix A
Required Knowledge	the elements of knowledge that an individual must acquire to adequately perform a task

The appendices located at the end of the analysis are described as follows:

Appendix A — Tools and Equipment	a non-exhaustive list of tools and equipment used in this trade
Appendix B — Glossary	definitions or explanations of selected technical terms used in the analysis
Appendix C — Acronyms	a list of acronyms used in the analysis with their full name
Appendix D — Block and Task Weighting	the block and task percentages submitted by each jurisdiction, and the national averages of these percentages; these national averages determine the number of questions for each block and task in the Interprovincial exam
Appendix E — Pie Chart	a graph which depicts the national percentages of exam questions assigned to blocks
Appendix F — Task Profile Chart	a chart which outlines graphically the blocks, tasks and sub-tasks of this analysis

DEVELOPMENT AND VALIDATION OF ANALYSIS

Development of Analysis

A draft analysis is developed by a committee of industry experts in the field led by a team of facilitators from HRSDC. This draft analysis breaks down all the tasks performed in the occupation and describes the knowledge and abilities required for a tradesperson to demonstrate competence in the trade.

Draft Review

The NOA development team then forwards a copy of the analysis and its translation to provincial and territorial authorities for a review of its content and structure. Their recommendations are assessed and incorporated into the analysis.

Validation and Weighting

The analysis is sent to all provinces and territories for validation and weighting. Participating jurisdictions consult with industry to validate and weight the document, examining the blocks, tasks and sub-tasks of the analysis as follows:

BLOCKS	Each jurisdiction assigns a percentage of questions to each block for an examination that would cover the entire trade.
TASKS	Each jurisdiction assigns a percentage of exam questions to each task within a block.
SUB-TASKS	Each jurisdiction indicates, with a YES or a NO, whether or not each sub-task is performed by skilled workers within the occupation in its jurisdiction.

The results of this exercise are submitted to the NOA development team who then analyzes the data and incorporates it into the document. The NOA provides the individual jurisdictional validation results as well as the national averages of all responses. The national averages for block and task weighting guide the Interprovincial Red Seal Examination plan for the trade.

This method for the validation of the NOA also identifies common core sub-tasks across Canada for the occupation. If at least 70% of the responding jurisdictions perform a sub-task, it shall be considered common core. Interprovincial Red Seal Examinations are based on the common core sub-tasks identified through this validation process.

Definitions for Validation and Weighting

YES	sub-task performed by qualified workers in the occupation in a specific jurisdiction
NO	sub-task not performed by qualified workers in the occupation in a specific jurisdiction
NV	analysis Not Validated by a province/territory
ND	trade Not Designated in a province/territory
NOT COMMON CORE (NCC)	sub-task, task or block performed by less than 70% of responding jurisdictions; these will not be tested by the Interprovincial Red Seal Examination for the trade
NATIONAL AVERAGE %	average percentage of questions assigned to each block and task in Interprovincial Red Seal Examination for the trade

Provincial/Territorial Abbreviations

NL	Newfoundland and Labrador
NS	Nova Scotia
PE	Prince Edward Island
NB	New Brunswick
QC	Quebec
ON	Ontario
MB	Manitoba
SK	Saskatchewan
AB	Alberta
BC	British Columbia
NT	Northwest Territories
YT	Yukon Territory
NU	Nunavut

ANALYSIS

SAFETY

Safe working procedures and conditions, accident prevention, and the preservation of health are of primary importance to industry in Canada. These responsibilities are shared and require the joint efforts of government, employers and employees. It is imperative that all parties become aware of circumstances that may lead to injury or harm. Safe learning experiences and work environments can be created by controlling the variables and behaviours that may contribute to accidents or injury.

It is generally recognized that safety-conscious attitudes and work practices contribute to a healthy, safe and accident-free work environment.

It is imperative to apply and be familiar with the Occupational Health and Safety (OH&S) Acts and Workplace Hazardous Materials Information System (WHMIS) Regulations. As well, it is essential to determine workplace hazards and take measures to protect oneself, co-workers, the public and the environment.

Safety education is an integral part of training in all jurisdictions. As safety is an imperative part of all trades, it is assumed and therefore it is not included as a qualifier of any activities. However, the technical safety tasks and sub-tasks specific to the trade are included throughout this analysis.

SCOPE OF THE TOOL AND DIE MAKER TRADE

"Tool and die maker" is this trade's official Red Seal occupational title approved by the CCDA. This analysis covers tasks performed by tool and die makers whose occupational title has been identified by some provinces and territories of Canada under the following names:

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
Die Maker					✓								
Mouldmaking Machinist					✓								
Tool and Die Maker	✓	✓	✓	✓		✓	✓		✓	✓			
Tool Maker					✓								

Tool and die makers design, create, repair and test prototypes and production tools such as dies, cutting tools, jigs, fixtures, gauges, and specialty tools using various metals, alloys and plastics. In some jurisdictions, they also build and repair moulds. They produce tooling used to manufacture and stamp out parts and they supply tooling and dies for all manufacturing sectors such as domestic consumer goods, transportation industry, medical, electronics, automotive and aerospace. They lay out, set up, machine, fit and finish metal components. They design and make items to meet exacting standards in dimensions, strength and hardness.

Tool and die makers use machining tools such as lathes, mills, saws, grinders, drills, computer numerical control (CNC) machines and Electrical Discharge Machines (EDM). They also use hand tools and measuring equipment to ensure accuracy and close tolerances. They work from sketches, drawings, computer-aided designs (CAD), specifications and their own concepts to calculate dimensions, tolerances and types of fit. They must be knowledgeable about the properties of metal and non-metallic materials such as plastic, rubber and composite materials.

Tool and die makers usually work indoors in tool rooms and machine shops in industry sectors where manufacturing and research is done. These may include industries that specialize in hardware and tooling, machinery equipment, motor vehicle parts, aerospace, research and development, transportation, high tech equipment or medical equipment.

Some tool and die makers may specialize in design, prototyping, automation equipment fabrication, tool and cutter making, heat treating, test equipment, gauge making, jig and fixture making, die making, mould making, assembly, inspection and programming.

Safety is important at all times. There are risks of injury working with moving machine parts, flying chips, sharp edges and extreme heat from heated materials. Tool and die makers may also be lifting and moving heavy components. Precautions are required while working with manufacturing chemicals, airborne irritants, toxic lubricants and cleaners.

Some attributes for people entering this trade are: communication skills, mechanical aptitude, attention to details, hand-eye coordination, manual dexterity, ability to work independently and in teams, logical reasoning ability, advanced knowledge of mathematics and applied science, creativity, resourcefulness, above average spatial ability and ability to plan and think sequentially. The work often requires considerable physical activity and stamina as tool and die makers spend long periods of time on their feet. Tool and die makers may work with other professionals such as machinists, mould makers, industrial mechanics (millwrights), designers, programmers and engineers.

Experienced tool and die makers may become business owners, managers or instructors. With additional training, they may transfer their skills to design and engineering responsibilities. Their skills are also transferable to related occupations such as machinist, mould maker, pattern maker, industrial mechanic (millwright) and CNC programmer.

OCCUPATIONAL OBSERVATIONS

The tool and die maker trade is changing rapidly throughout the various industries in Canada and worldwide. Technology is quickly changing the basic trade. Advances in CNC, robotics, laser, exotic materials and composites will continue to impact the trade in future years. Knowledge and skill levels continue to increase in this trade. The tool and die maker must be adaptable to technological changes.

Experienced tool and die makers are becoming more accountable and responsible for steps or operations they were not involved in previously. For example, tool and die makers are often project leaders and have the responsibility and authority for the different steps that lead to the final product. Therefore, there is an increased need to develop team working skills. Due to those new responsibilities, tool and die makers are engaged in the early stages of project development involving clients, engineers, and marketing teams.

Alternately, there are also instances of specialization in certain areas of the trade. This may affect the mobility of individual tool and die makers.

ESSENTIAL SKILLS SUMMARY

Essential skills are needed for work, learning and life. They provide the foundation for learning all other skills and enable people to evolve with their jobs and adapt to workplace change.

Through extensive research, the Government of Canada and other national and international agencies have identified and validated nine essential skills. These skills are used in nearly every occupation and throughout daily life in different ways.

A series of CCDA-endorsed tools have been developed to support apprentices in their training and to be better prepared for a career in the trades. The tools can be used independently or with the assistance of a tradesperson, trainer, employer, teacher or mentor to:

- understand how essential skills are used in the trades;
- learn about individual essential skills strengths and areas for improvement; and
- improve essential skills and increase success in an apprenticeship program.

The tools are available online or for order at: www.hrsdc.gc.ca/essentialskills.

The essential skills profile for the tool and die maker trade indicates that the most important essential skills are **document use**, **numeracy** and **thinking skills**.

The application of these skills may be described throughout this document within the competency statements which support each subtask of the trade. The following are summaries of the requirements in each of the essential skills, taken from the essential skills profile. A link to the complete essential skills profile can be found at www.red-seal.ca.

Reading

Tool and die makers use reading skills to comprehend instructions and safety warnings on product and equipment labels. They also have to read reference material, product descriptions, work instructions on work orders and job files, policies and procedures applicable to the work they carry out and operating, safety and equipment manuals. Tool and die makers also need to read about new trends, technological developments, tooling practices and procedures in industry, trade and safety publications.

Document Use
Tool and die makers need strong document use skills to locate data in charts and tables such as material composition sheets, specification tables and conversion tables. They also locate and complete information on tracking and quality control forms. Tool and die makers take data from and interpret a variety of graphs and graphical displays, and they locate dimensions and other features on complex shop drawings to fabricate parts and assemble production tools. Tool and die makers also require document use skills to examine perspective views and assembly drawings to understand and visualize the location, orientation and function of complex components and sub-assemblies.

Writing
Tool and die makers write comments in daily logbooks to create records and inform supervisors and co-workers. They may write e-mails and memos to customers, supervisors, engineers and technicians to provide and request information. Tool and die makers also write a variety of reports such as quality assurance and equipment repair logs. They also prepare estimating and work planning sheets.

Numeracy
Tool and die makers need advanced numeracy skills. They require skills to establish timelines, set sequence of operations, calculate the time required to complete each sub-assembly and determine project progress against timelines. Tool and die makers use measurement and calculation skills to take a variety of measurements to ensure conformance to specifications. These skills are also required to analyze the geometry of fabricated parts, to verify dimensions, distances and angles of design features, and to calculate cutting parameters such as speeds and feeds. Several trigonometric functions and mathematical formulas are used frequently in the day-to-day work of tool and die makers. Some calculations include speeds and feeds, and tolerance stack-up on machine parts and geometric interrelationships between parts features.

Tool and die makers also use data analysis skills to compare instrument readings such as temperature, pressure and size to interpret fabrication process data and to analyze performance data for production tool sets under controlled and simulated conditions.

Finally, numerical estimation skills are used to estimate how much stock tool and die makers require to make components for production tools, to estimate the initial machine and equipment settings for testing production tool sets and producing prototypes, and to estimate the time required to complete jobs.

Oral Communication
Tool and die makers need good oral communication skills to communicate with supervisors and co-workers to coordinate tasks, in order to carry out activities correctly, safely and efficiently. They offer suggestions and advice on design features, materials and tooling procedures to improve quality and production efficiency. They also discuss design modifications with engineers and request technical information from them. They may give instructions, provide directions and offer explanations to apprentices and helpers.

Thinking Skills

Tool and die makers need strong thinking skills. Their problem solving skills are required when they discover that specifications are incorrect or need modifications, when they encounter problems with fabrication processes and when they find that malfunctioning equipment makes further fabrication impossible. The problem solving skills are then used to work with engineers, quality control personnel and co-workers to identify failures and corrective action requirements.

Tool and die makers also use decision making skills to decide the sequence of operations such as assembly sequence and the machining sequence of parts, and to select the types of materials, supplies, tools, tooling paths and machines to use.
Critical thinking skills are also required to evaluate the quality and acceptability of fabricated production tools to assess the suitability of specified materials and to evaluate the feasibility and technical soundness of production tool designs from both fabrication and quality perspectives.

Tool and die makers need job task planning and organizing skills as they are responsible for setting the sequence of tasks for the projects they are assigned.

Working with Others

Tool and die makers work as team members with engineers, quality control personnel and co-workers when designing production tools, and diagnosing and resolving faults in equipment, production tools and other products. They may work with technical experts to coordinate fabrication and assembly of parts and machines.

Computer Use

Tool and die makers use databases to enter and retrieve information about current and past fabrication jobs. They also need computer skills when working with CAD, computer-aided manufacturing (CAM), and data transfer to CNC machine-tool controls.

Continuous Learning

Tool and die maker employers may offer training for skills development, new equipment, and health and safety training. However, much of their learning occurs day-to-day through the challenges and problems that arise during the course of each project and from discussions with more senior tool and die makers and other co-workers. They also read reference material to increase their trade knowledge, and industry publications to stay current on trends and new technologies.

BLOCK A COMMON OCCUPATIONAL SKILLS

Context

Tool and die makers perform safety-related functions and use various tools and equipment to complete multiple tasks throughout their trade. They also use and maintain machine-tools and tooling in order to prolong service life and to ensure a safe environment. Tool and die makers also use organizational skills to perform their tasks in a safe, efficient and effective manner. The benchwork that tool and die makers perform is multi-functional; it takes in many various critical components of the trade from part layout to part fit-up to produce a finished component to exacting standards.

Trends

Safety standards are becoming more rigorous and require more thorough applications of practices. Safety officers and inspectors are becoming more common in the workplace.

The implementation of shop floor management systems (software) is becoming more common. That software facilitates the planning and scheduling process.

Related Components

All components apply.

Tools and Equipment

See Appendix A.

Task 1 Performs safety-related functions.

Required Knowledge

K 1	types of personal protective equipment (PPE) such as respiratory, hearing, eye and body protection
K 2	PPE and safety equipment operations
K 3	Occupational Health and Safety (OH&S)
K 4	location of PPE and safety equipment
K 5	jurisdictional safety regulations
K 6	types and operation of fire extinguishing equipment
K 7	disposal and recycling procedures

K 8	work hazards such as toxic chemicals and metals, and the improper operation of hand and power tools
K 9	absorbent materials
K10	lockout procedures
K11	dangerous conditions and potential hazards
K 12	required training and certification
K 13	Workplace Hazardous Materials Information System (WHMIS) and Material Safety Data Sheets (MSDS)
K 14	first aid
K 15	company safety policy
K 16	signage
K 17	required ventilation

Sub-task

A-1.01 **Maintains safe work environment.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-1.01.01	comply with lock-out and tag-out procedures
A-1.01.02	recognize worksite hazards such as slippery floors, tangled air lines and power cords, and hazardous fumes
A-1.01.03	recognize machine hazards such as hot or irregular chip formation, insecurely mounted workpiece, defective equipment and contaminated coolant
A-1.01.04	stack and store parts and materials in designated locations and formations
A-1.01.05	follow specified safety procedures such as using safety glasses and safety shoes, and following evacuation procedures
A-1.01.06	maintain a clean and tidy work area to avoid injuries to self and others
A-1.01.07	identify hazardous tasks performed among workers to avoid injuries to self and others
A-1.01.08	handle hazardous materials in accordance with WHMIS procedures such as disposal, labelling and use of PPE
A-1.01.09	participate in safety meetings and discussions
A-1.01.10	set up barricading devices and signage such as caution tape, fences and barriers to define work perimeters and contain contaminants or other hazards

A-1.01.11	set up or identify location of safety zone containing components such as first aid kit, fire extinguishers, MSDS and eye wash stations
A-1.01.12	document items such as faulty PPE and safety equipment, inspections, potential hazards, safety meetings, injuries and training according to jurisdictional regulations
A-1.01.13	obtain required certification for regulated devices

---

Sub-task

A-1.02 **Uses personal protective equipment (PPE) and safety equipment.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-1.02.01	identify site hazards and regulations requiring the use of PPE and safety equipment
A-1.02.02	maintain and store PPE and safety equipment
A-1.02.03	identify and replace damaged PPE such as excessively worn boots and cracked safety glasses or face shields
A-1.02.04	recognize Canadian Standards Association (CSA) approved PPE and applicable safety equipment such as fire extinguishers, breathing apparatus, hearing protection and safety shoes
A-1.02.05	select and use PPE and safety equipment appropriate for individual tasks and situations
A-1.02.06	ensure proper fit of PPE such as respirators, fall arrest harnesses and face shields

---

Task 2 Uses and maintains machine-tools and tooling.

Required Knowledge

K 1	types of hand tools
K 2	imperial and metric systems
K 3	types of power tools such as electric, pneumatic and hydraulic
K 4	operating procedures

K 5	types of measuring devices such as micrometers, vernier calipers, protractors, sine bars and gauge blocks
K 6	measuring device calibration
K 7	types of layout tools and equipment such as height gauges, angle plates, scribers and surface tables
K 8	types of hoisting and lifting equipment such as jacks, chain hoists and overhead cranes
K 9	hoisting, lifting and rigging procedures
K 10	jurisdictional requirements to operate forklifts and cranes
K 11	cleaning equipment, techniques and their requirements
K 12	machine lockout procedures
K 13	types of lubricants and machine requirements
K 14	maintenance schedule
K 15	tool geometry such as rake angles, relief angles and chip breakers
K 16	types of tool sharpening equipment
K 17	types of cutting fluids such as oil and water soluble fluids
K 18	machine operations and accessories
K 19	types of alignment equipment
K 20	equipment and procedures used in calibration of inspection equipment
K 21	techniques and procedures for storing, handling and maintenance of equipment, materials and tooling

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Sub-task

A-2.01 Uses hoisting and lifting equipment.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-2.01.01	select and use forklifts and cranes in accordance with specified practices
A-2.01.02	determine approximate weight of lift to stay within capacity of available equipment
A-2.01.03	recognize shop and regulatory limitations and determine what rigging and hoisting operations need to be done by qualified personnel
A-2.01.04	inspect hoisting, lifting and rigging equipment for defects according to specified schedule

A-2.01.05	take out of service, mark and report defective equipment
A-2.01.06	store equipment in clean and dry locations
A-2.01.07	select and use slings, chains, wire ropes and other accessories

Sub-task

A-2.02 Maintains machine-tools and tooling.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-2.02.01	clean machine-tools and tooling
A-2.02.02	check oil levels and lubricate accordingly
A-2.02.03	maintain level and quality of cutting fluids and coolants
A-2.02.04	ensure compliance with maintenance schedule
A-2.02.05	maintain quality and performance of machine-tools, spindles, holders, chucks, cutting tools and other accessories

Task 3 Organizes work.

Required Knowledge

K 1	types of drawings and drawing notes
K 2	first and third angle projection
K 3	symbols such as surface finishes, scales and tolerances
K 4	machine-tools and machining operations
K 5	material characteristics such as composition, properties, application and machinability
K 6	material non-destructive tests such as dye penetrant and x-ray tests
K 7	material hardness tests such as Rockwell and Brinell
K 8	time required to complete each operation
K 9	types and grades of material such as metals and non-metallic materials
K 10	heat treating procedures including torch, quenching, tempering, annealing, normalizing and carburizing
K 11	heating mediums such as gas, electric and vacuum furnaces, and gas torches

K 12	standards such as American National Standards Institute (ANSI), CSA and Society of Automotive Engineers (SAE)
K 13	design and development of production tools and prototypes

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Sub-task

A-3.01 Interprets drawings, specifications and applications.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-3.01.01	determine information such as number of parts to make, engineered components and material to be used, and machines to be used
A-3.01.02	check drawing for dimensioning, machining allowances and conflicting information
A-3.01.03	visualize finished product by analyzing dimensions and drawings
A-3.01.04	use process sheet to determine order of operations
A-3.01.05	locate information in reference materials such as *Machinery's Handbook*
A-3.01.06	perform mathematical calculations to augment information provided by documentation
A-3.01.07	refer to standards such as material certification, SAE, American Society of Mechanical Engineering (ASME) and military specifications (MILSPEC)

Sub-task

A-3.02 Plans project activities.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-3.02.01	identify and confirm resources required such as components, machinery, materials and processes
A-3.02.02	identify tasks to manufacture production tools and prototypes such as preparing materials, performing benchwork, sawing, turning, grinding, milling and assembling
A-3.02.03	estimate timelines for each task

A-3.02.04	prioritize operations into a logical sequence
A-3.02.05	establish milestones by determining a schedule of operations
A-3.02.06	verify feasibility of schedule by confirming availability of identified resources

Task 4 — Performs benchwork.

Required Knowledge

K 1	types and grades of material such as metals and non-metallic materials
K 2	material characteristics such as composition, properties, application and machinability
K 3	material identification markings such as ASME system, ANSI system, colour codes and number system
K 4	raw material measurements
K 5	layout procedures
K 6	layout media such as dyes, paint, markers and coating
K 7	marking procedures such as etching, engraving, colour coding and stamping
K 8	types of material defects
K 9	inspection procedures and techniques such as incoming, in-process and final
K 10	types of layout and inspection equipment such as micrometers, dividers, height gauges, vernier calipers, protractors, and hardness testers
K 11	dimensioning practices such as geometric dimensioning and tolerancing (GDT)
K 12	sketching techniques
K 13	types of projections such as first angle and third angle
K 14	deburring techniques such as filing, stoning and scraping
K 15	lapping and honing techniques
K 16	polishing and blending techniques
K 17	types of abrasives

Sub-task

A-4.01 **Performs layout.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-4.01.01	determine layout requirements by reading engineering drawings and specifications
A-4.01.02	select and use layout tools and instruments such as surface plates, layout dye, scribers, height gauges and prick punches
A-4.01.03	scribe workpiece to identify and locate part features according to drawing specifications
A-4.01.04	verify layout by using measuring tools such as vernier calipers, dividers and steel rules

Sub-task

A-4.02 **Marks material for identification.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-4.02.01	follow coding system used in shop to maintain organization of inventory
A-4.02.02	etch or stamp required information such as heat numbers, parts numbers and composition
A-4.02.03	mark workpiece without compromising the integrity of the workpiece

Sub-task

A-4.03 **Inspects workpiece.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-4.03.01	perform inspection techniques using equipment such as vernier calipers, micrometers, dial indicators, optical comparators and coordinate measuring machines (CMM)
A-4.03.02	perform basic non-destructive inspection (dye penetrant)
A-4.03.03	perform visual inspection of workpiece for defects such as cracks, inadequate surface finish, distortions, surface deviation and damage

Sub-task

A-4.04 **Finishes workpiece.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

A-4.04.01	select finishing process such as lapping, honing, deburring, filing, and polishing according to job specifications
A-4.04.02	select abrasives such as hones, stones and lapping compounds
A-4.04.03	identify features to be deburred
A-4.04.04	select required work holding devices such as vises, soft jaws, parallel clamps and C-clamps
A-4.04.05	set up workpiece in work holding device to protect material and operator
A-4.04.06	perform finishing technique to achieve required finish
A-4.04.07	use comparators and measure workpiece throughout the process to make finish adjustments
A-4.04.08	identify process problems such as scratching and rounded edges
A-4.04.09	clean workpiece to remove debris

A-4.04.10	verify workpiece meets specifications using inspection equipment such as precision squares, vernier calipers, surface finish comparators and micrometers
A-4.04.11	protect finished workpiece using material such as rust inhibitor, paper and crating

BLOCK B MACHINE-TOOL SETUP AND OPERATION

Context

Tool and die makers determine the sequence of machining operations and equipment required to produce the end product in the most efficient manner. To do so, they use various techniques and machine-tools such as conventional drills, lathes, milling machines, grinders and saws, and computer numerical control (CNC) machines and Electrical Discharge Machines (EDM).

Trends

The continued increase in the use of CNC machines and new machining processes such as water jet cutting, laser cutting and high speed machining are influencing the tool and die industry by making the machining process more efficient and cost effective.

The effect on tool and die makers is less direct involvement in the machining of production tool components. This means tool and die maker skills are focussed more on planning, costing, final fitting, assembly, try-outs, development and proving out of tooling.

Related Components

Not applicable.

Tools and Equipment

See Appendix A.

Task 5 Plans and prepares for machine-tool operations.

Required Knowledge

K 1	machine operations and sequencing
K 2	machine capacity and capabilities
K 3	types of machine-tools such as lathes, drills, grinders, saws and milling machines
K 4	work holding devices and equipment
K 5	machining accessories
K 6	limits and capabilities of tooling, accessories and holding devices

K 7	fragile items such as thin wall components and tool sensors
K 8	clamping pressures and alignment
K 9	types of tooling such as high speed steel (HSS), carbide tooling and carbide inserts
K 10	installation and positioning techniques of types of tool holders
K 11	machine speeds and feeds
K 12	tool geometry such as rake angles, relief angles and chip breakers
K 13	thread types such as Unified National Fine (UNF), Unified National Coarse (UNC), Acme, National Pipe Taper (NPT), National Pipe Straight (NPS) and metric
K 14	types of alignment equipment such as dial indicator, precision level and square
K 15	calibration equipment and procedures

Sub-task

B-5.01 Plans machining sequence.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-5.01.01	review drawings and sketches pertaining to current task to ensure accuracy of procedure, finishes and machining allowances
B-5.01.02	determine type of equipment such as mills, lathes, grinders, drill presses and power saws
B-5.01.03	establish the sequence of machining operations
B-5.01.04	match accessories and work holding devices to workpiece requirements
B-5.01.05	select cutting tool such as HSS, carbide tooling and inserts according to material type and machining requirements

Sub-task

B-5.02 **Establishes workpiece datum.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-5.02.01	verify location of work datum by referring to drawings and sketches
B-5.02.02	select alignment instruments such as probes, edge finders and dial indicators
B-5.02.03	touch off designated datum surfaces of workpieces using tools such as probes and edge finders

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Sub-task

B-5.03 **Sets up work holding devices in machine-tools.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-5.03.01	select machine-tool work holding devices such as vises, V-blocks, drive plates, angle plates, chucks, collets, steady rests, face plates and magnetic chucks
B-5.03.02	position, align and secure work holding device to match workpiece requirements
B-5.03.03	apply clamping forces according to characteristics of part and cutting forces

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Sub-task

B-5.04 **Sets up machine tooling and accessories.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-5.04.01	install and mount tooling and inserts in tool holders
B-5.04.02	mount tool holder in machines

B-5.04.03	position and align accessories using tools such as dial indicators, gauge blocks and squares
B-5.04.04	join band saw blades
B-5.04.05	perform calculations such as taper and parallelism correction
B-5.04.06	perform presetting of machine cutting tools
B-5.04.07	adjust, position and secure drill press accessories such as jigs, fixtures and work holding devices
B-5.04.08	adjust, position and secure lathe accessories such as taper attachments, steady rests and follower rests
B-5.04.09	adjust, position and secure milling accessories such as rotary tables, vises, universal dividing heads and boring heads
B-5.04.10	adjust, position and secure grinding accessories such as angle plates, collets, steady rests, chucks, drive dogs and mandrels.

Sub-task

B-5.05 Sets up workpiece in machine-tool.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-5.05.01	orientate workpiece in the work holding device
B-5.05.02	fasten and secure workpiece into work holding devices such as collets, chucks, V-blocks, angle plates and vises

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Sub-task

B-5.06 Selects speeds and feeds of machine-tools.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-5.06.01	determine rigidity of machine tool, workpiece and setup
B-5.06.02	calculate speeds and feeds according to machining requirements

Task 6 — Operates conventional drill presses, lathes and milling machines.

Required Knowledge

K 1	drilling techniques such as pecking, centre drilling and deep hole drilling
K 2	work holding size and types for selected operation
K 3	counterbore diameter and corresponding pilot diameter
K 4	required surface finish
K 5	tap types such as spiral flute, spiral point and form taps
K 6	thread types such as UNF, UNC, Acme, NPT, NPS and metric
K 7	cutting tool geometry
K 8	tools and tool holders
K 9	types of parting tools such as carbide and HSS
K 10	hole finishing techniques such as drilling, reaming, boring and honing
K 11	grooving tool materials such as carbide and HSS
K 12	procedures and techniques to produce internal and external threads
K 13	single and multi-start threads
K 14	methods of milling such as climb milling and conventional milling
K 15	horizontal and vertical milling
K 16	types and applications of specialized cutters
K 17	procedures for cutting pockets, profiles and keyways
K 18	procedures for turning tapers such as using taper turning attachments, compound rests and tail stock offsets
K 19	procedures for knurling, parting, grooving and contouring

Sub-task

B-6.01 **Performs hole making and finishing operations.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-6.01.01	read documentation to determine operations to be performed
B-6.01.02	assess hole requirements to determine tooling such as countersinks, counterbores, chamfering tools, spot faces, centre drills, spot drills, pilot drills, drills and boring heads
B-6.01.03	select and set up tooling such as drills, reamers, boring bars, countersinks and spot faces according to operation
B-6.01.04	perform visual inspection of tool for wear and damage
B-6.01.05	install drill chuck into tail stock, drill press and milling machine
B-6.01.06	mount drill for application
B-6.01.07	set up and secure workpiece
B-6.01.08	touch off drill to workpiece surface to establish a reference point
B-6.01.09	pre-drill workpiece using tooling such as centre drills and pilot drills
B-6.01.10	feed drill into workpiece to produce hole
B-6.01.11	apply cutting fluids for lubrication, cooling and chip removal
B-6.01.12	apply tapping procedures according to machine-tool type
B-6.01.13	identify process problems such as drill wandering, oversized holes, misalignment of tail stock/turret, incorrect speeds and feeds, wrong depth of cut, incorrect cutter geometry, tool wear, insufficient coolant, chip removal and damage to cutting tool
B-6.01.14	measure and check hole throughout the process to make adjustments
B-6.01.15	finish hole and hole features using tooling such as drills, reamers, boring bars, boring heads, taps and tapping heads according to requirements
B-6.01.16	verify holes and hole features meet specifications using inspection equipment such as telescopic gauges, optical comparators, small hole gauges, pin gauges, go no-go gauges, thread gauges, dial indicators and vernier calipers

Sub-task

B-6.02 **Turns surfaces using lathe.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-6.02.01	read documentation to determine operations to be performed
B-6.02.02	perform visual inspection of tool for wear and damage
B-6.02.03	position and secure workpiece using work holding devices such as chucks, collets and steady rests
B-6.02.04	touch off tool on workpiece to establish primary reference
B-6.02.05	turn internal and external surfaces
B-6.02.06	set compound rest, taper attachment or tail stock offset to required angle
B-6.02.07	rough-turn to remove material and to prepare for finishing operation
B-6.02.08	produce contours using tools such as templates and form tools
B-6.02.09	measure workpiece throughout the process to make adjustments
B-6.02.10	identify process problems such as chatter, tool deflection, taper and run-out
B-6.02.11	finish-turn to comply with specifications
B-6.02.12	verify workpiece meets specifications using inspection equipment such as micrometers, depth micrometers, dial indicators, templates and vernier calipers

Sub-task

B-6.03 **Faces surfaces using milling machine.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-6.03.01	read documentation to determine operations to be performed
B-6.03.02	perform visual inspection of tool for wear and damage
B-6.03.03	position and secure workpiece using work holding devices such as chucks, collets, vises, angle plates and sine plates
B-6.03.04	machine vertical, horizontal and angled surfaces
B-6.03.05	touch off tool on workpiece to establish primary reference points (datum)

B-6.03.06	measure workpiece to determine amount of excess material using inspection equipment such as depth micrometers, gauge blocks and dial indicators
B-6.03.07	remove required amounts of excess material to meet specifications
B-6.03.08	measure workpiece throughout the process and make required adjustments
B-6.03.09	identify process problems such as incorrect speeds and feeds, wrong depth of cut, incorrect cutter geometry, insufficient coolant, chatter, tool wear and incorrect tool height setting
B-6.03.10	finish-face to comply with specifications
B-6.03.11	verify workpiece meets specifications using inspection equipment such as gauge blocks, micrometers, vernier calipers, straight edges, squares, surface finish comparators and dial indicators

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Sub-task

B-6.04 **Performs parting, grooving and knurling using lathe.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-6.04.01	read documentation to determine operations to be performed
B-6.04.02	select tools such as parting and grooving tools
B-6.04.03	select knurling wheels for pattern and size
B-6.04.04	perform visual inspection of tool for wear and damage
B-6.04.05	measure tool location from reference point
B-6.04.06	set up and position workpiece for grooving internal and external surfaces
B-6.04.07	touch off tool on workpiece to establish primary reference points (datum)
B-6.04.08	apply cutting fluids for lubrication, cooling and chip removal
B-6.04.09	apply knurling procedures
B-6.04.10	visually inspect workpiece throughout the process
B-6.04.11	identify process problems such as tool wear, incorrect speeds and feeds, depth of cut, cutter geometry, insufficient coolant, chattering, galling, flaking, tool wandering and chip removal
B-6.04.12	measure roughed-out workpiece to make finish adjustments
B-6.04.13	finish the workpiece to comply with specifications

B-6.04.14	verify workpiece meets specifications using inspection equipment such as micrometers, gauge blocks, vernier calipers, straight edges and sample piece
B-6.04.15	ensure parted workpiece is retained without damage to workpiece or equipment

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Sub-task

B-6.05 **Cuts internal and external threads using lathe.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-6.05.01	read documentation to determine operations to be performed
B-6.05.02	perform visual inspection of tool for wear and damage
B-6.05.03	set up machine to cut external or internal threads
B-6.05.04	set up lathe to cut internal or external multi-start threads
B-6.05.05	adjust gear box for required thread pitch
B-6.05.06	set up compound rest to required angle
B-6.05.07	grind cutting tools to produce thread form
B-6.05.08	use center gauge to establish required angle on tool
B-6.05.09	touch off tool on workpiece to establish primary reference (datum)
B-6.05.10	produce threads using accessories such as die heads, tapping heads and taper attachments
B-6.05.11	cut a test pass to verify thread pitch
B-6.05.12	cut thread to required specifications
B-6.05.13	measure thread pitch diameter using thread wires
B-6.05.14	identify process problems such as chatter, tool deflection and taper
B-6.05.15	deburr threaded workpiece to remove sharp edges
B-6.05.16	verify final workpiece dimensions using inspection equipment such as thread wires, thread micrometers, go no-go gauges, sample pieces and shadow graph

Sub-task

B-6.06 **Performs profiling, pocketing and slotting using milling machine.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-6.06.01	read documentation to determine operations to be performed
B-6.06.02	perform visual inspection of tool for wear and damage
B-6.06.03	position and secure workpiece in work holding device
B-6.06.04	perform profile calculations
B-6.06.05	use edge finder or dial indicator to locate datum surface
B-6.06.06	touch off milling cutter to workpiece surface to establish a reference point
B-6.06.07	cut profiles using accessories such as rotary tables and indexing heads
B-6.06.08	apply cutting fluids to remove chips and to cool workpiece and tools
B-6.06.09	rough out workpiece using tooling such as indexable carbide cutters, roughing end mills and radius cutters
B-6.06.10	identify process problems such as incorrect speeds and feeds, incorrect depth of cut, incorrect cutter geometry, tool wear, insufficient coolant and chip removal
B-6.06.11	measure roughed-out workpiece to make finish adjustments
B-6.06.12	finish workpiece using tooling such as carbide end mills, dovetail cutters, woodruff cutters, radius cutters and T-slot cutters
B-6.06.13	verify workpiece meets specifications using inspection equipment such as gauge blocks, radius gauges, micrometers, vernier calipers and dial indicators

Task 7 Operates power saws.

Required Knowledge

K 1	types and capabilities of power saws such as vertical, horizontal, reciprocating and circular
K 2	capacity of saw such as speed, feed and size
K 3	work holding and supporting devices such as infeed support and outfeed support
K 4	blade sizes, set, tooth pitch and composition

K 5	types of blade guides such as carbide, roller and bearing
K 6	blade effect on cutting rate, tool life, finish and accuracy
K 7	break-in period of new blades
K 8	blade installation techniques and procedures for various saw types
K 9	workpiece characteristics such as shape, material and size
K 10	clamping pressures
K 11	saw features such as manual stops, automatic indexing devices and programmable logic controller (PLC) devices
K 12	types of power saw accessories such as nesting fixtures, fences, gravity feed and vises
K 13	band saw blade welding procedures such as butt welding and silver soldering

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Sub-task

B-7.01 **Saws straight and angle cuts.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-7.01.01	select saw blades and tooth pitch according to material type and thickness
B-7.01.02	apply cutting fluid to remove chips and to cool saw blade
B-7.01.03	guide workpiece into vertical band saw blade using a pusher guide (push stick) with consistent cutting pressure to protect blade and provide an efficient cut
B-7.01.04	adjust angle of vise on horizontal saw according to required angle of cut
B-7.01.05	monitor straightness of cut during cutting process
B-7.01.06	square off end of material (reference cut) to ensure an accurate measurement
B-7.01.07	identify process problems such as incorrect speeds and feeds, and binding or overheating blade
B-7.01.08	verify workpiece meets specifications using inspection equipment such as protractors, tape measures and machinist square

Sub-task

B-7.02 Cuts irregular shapes.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-7.02.01	select saw blade width, pitch and kerf according to required profile (contour)
B-7.02.02	feed material and follow contour layout line
B-7.02.03	apply cutting fluid to remove chips and to cool saw blade
B-7.02.04	guide workpiece into vertical band saw blade using a pusher guide (push stick) with consistent cutting pressure to protect blade and provide an efficient cut
B-7.02.05	monitor angle of cut during cutting process
B-7.02.06	identify process problems such as incorrect speeds, feeds, and binding or overheating blade
B-7.02.07	verify workpiece meets specifications using inspection equipment such as templates and radius gauges

Task 8 Operates grinders.

Required Knowledge

K 1	types of grinding machines such as surface, cylindrical, and tool and cutter
K 2	capacity of grinding machine
K 3	grinding machine accessories such as support rests and power heads
K 4	types, sizes and grades of grinding wheels such as cubic boron nitride (CBN), aluminium oxide and silicon carbide
K 5	grinding machine operations such as surface, cylindrical, and tool and cutter
K 6	sequence of grinding machine operations
K 7	types of work holding devices such as centres, four-jaw chucks, three-jaw chucks, face plates, fixtures, magnetic chucks and magnetic sub-plates
K 8	clamping pressure
K 9	capacity of work holding device
K 10	techniques and procedures for storing, handling and mounting grinding wheels

K 11	blotter applications
K 12	balancing techniques and procedures
K 13	truing and dressing techniques and procedures such as contour dressing and diamond dressing
K 14	types of accessories such as rests, internal grinding head, wheel dressers, laminated blocks, magnetic spring clamps, chucks, drive dogs and mandrels
K 15	contact material for steady rests and follower rests such as bronze pads, polymer pads and brass pads
K 16	workpiece characteristics such as shape, material and size
K 17	setup and alignment techniques such as shimming, dialling-in and using sine bars
K 18	effect of speeds, feeds and depth of cut on finish and wheel life
K 19	surface grinding techniques required to produce surfaces such as parallel, flat and square
K 20	cylindrical and surface grinding techniques to produce profiles such as angles, vees, radii, recesses, shoulders and special forms
K 21	setup and alignment techniques for machine accessories such as drive plates, grinder carriers, drive dogs, trip dogs, foot stock, centres, chucks, work heads and wheel heads
K 22	types of tool and cutter grinders such as drill grinders and end mill grinders
K 23	cutter types such as form relief cutters, reamers and end mills
K 24	relief angles and clearances
K 25	honing machines and techniques

Sub-task

B-8.01 Mounts grinding wheel.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-8.01.01	visually inspect grinding wheel for defects such as cracks, stains and gouges
B-8.01.02	ring test grinding wheel for internal cracks
B-8.01.03	balance grinding wheel using wheel balancing equipment such as mandrels and weights
B-8.01.04	secure grinding wheel on required adapters using blotters and flanges
B-8.01.05	install balanced wheel assembly on machine

B-8.01.06	select truing and dressing tools according to profile
B-8.01.07	true and dress mounted grinding wheel using diamond dressing tools
B-8.01.08	assess further balancing requirements of installed grinding wheel

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Sub-task

B-8.02 Grinds flat surfaces.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-8.02.01	touch off grinding wheel on workpiece surface to establish a reference point
B-8.02.02	measure workpiece to determine amount of excess material using inspection equipment such as depth micrometers, gauge blocks and dial indicators
B-8.02.03	remove required amounts of excess material to meet specifications
B-8.02.04	identify surface finish defects caused by process problems such as incorrect speeds and feeds, depth of cut and wheel loading, and incorrect consistency of coolant
B-8.02.05	verify flat surface meets specifications using inspection equipment such as profilometers, micrometers, surface finish comparators and dial indicators

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Sub-task

B-8.03 Grinds profiles and tapered surfaces.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-8.03.01	select profile grinding machine such as surface, universal and cylindrical grinder
B-8.03.02	position and secure workpiece to work holding device
B-8.03.03	dress grinding wheel to desired profile using tools such as radius dressing attachment, dressing stick (stone) and diamond dressing tool
B-8.03.04	measure workpiece to determine amount of excess material using inspection equipment such as depth micrometers, sine bars, contour gauge and dial indicators

B-8.03.05	touch off grinding wheel on workpiece surface to establish a reference point
B-8.03.06	perform internal, external, plunge or traverse grinding
B-8.03.07	rough out workpiece profile to remove excess material leaving a finish grinding allowance
B-8.03.08	verify profile meets specifications using inspection equipment such as contour gauges, surface finish comparators and dial indicators

Task 9 — Operates computer numerical control (CNC) machines.

Required Knowledge

K 1	CNC machine controls
K 2	programming codes such as G, M and S
K 3	parameters to establish work datum
K 4	types of offsets and compensations such as length, diameter and tool nose radius
K 5	load monitoring system
K 6	machine alarms and alarm codes
K 7	Cartesian Coordinate System
K 8	sequence of CNC machining operations
K 9	conversational programming
K 10	absolute and incremental programming methods

Sub-task

B-9.01 Performs basic CNC programming.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-9.01.01	interpret workpiece documentation such as setup sheets and engineering drawings
B-9.01.02	locate information required for CNC machining such as part origin, orientation and location of work holding devices
B-9.01.03	determine types of cutting tools to be used in machining operation

B-9.01.04	generate program points using trigonometry and Cartesian Coordinate System
B-9.01.05	use software and built-in features of the machine control to generate cutter paths
B-9.01.06	designate offsets for tool nose radius, cutter radius, approach vectors and tool length compensation
B-9.01.07	plan entry and exit moves to engage or cancel cutter compensation
B-9.01.08	establish safety blocks of code in order to cancel previous code and initialize machine at a start point
B-9.01.09	use G code and conversational method to produce program
B-9.01.10	interpret and review codes from program

Sub-task

B-9.02 **Inputs program data into control memory.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-9.02.01	select and download program from personal computer (PC), network or storage devices to CNC controller
B-9.02.02	manually input program data
B-9.02.03	edit program using input functions such as "insert", "alter" and "delete"

Sub-task

B-9.03 **Sets up workpiece datum.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-9.03.01	verify location of work datum by referring to setup sheets
B-9.03.02	manually adjust machine axes to locate designated datum surfaces of workpiece using tools such as probes, dial indicators and edge finders
B-9.03.03	establish tool length such as pre-set and touch off cutting tool on suitable reference surface
B-9.03.04	input datum information into specific machine offset register as determined by setup sheet or tooling list

Sub-task

B-9.04 **Verifies programs.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-9.04.01	confirm program reference number
B-9.04.02	perform dry run in single block mode or graphic simulation of program in order to verify datum, tool path and tool sequence
B-9.04.03	use features such as single block mode, distance to go, feed hold and feed override to step through program to avoid cutting tool interference with work holding devices
B-9.04.04	modify program as required, then confirm and retain program modifications and update master file

Sub-task

B-9.05 Monitors machining processes.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-9.05.01	recognize signs of tool wear such as poor finish, vibration and excessive noise
B-9.05.02	assess tool wear by reading spindle and drive axis load meters, and checking workpiece sizes
B-9.05.03	recognize chip control problems
B-9.05.04	use machine overrides such as rapid override, and speed and feed override
B-9.05.05	verify adequate coolant or air flow to facilitate chip removal, and maintain required surface finish and tool life
B-9.05.06	correct problems such as chatter, tool failure, poor finishes and abnormal chip formations by adjusting speed and feed overrides
B-9.05.07	restart program at correct tool and machine position once problems are corrected
B-9.05.08	measure workpiece dimensions
B-9.05.09	adjust offset values by calculating deviations according to workpiece dimensions

Task 10 Operates Electrical Discharge Machines (EDM).

Required Knowledge

K 1	specific hazards such as fire and electric shock
K 2	types of EDMs such as wire EDM and sink EDM
K 3	functions and capabilities of EDMs
K 4	types of dielectric fluids
K 5	fluid pressures
K 6	types of electrode materials
K 7	wire diameters and materials
K 8	electrode sizes
K 9	power settings

Sub-task

B-10.01 **Determines flushing methods.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-10.01.01	select fluid for required application
B-10.01.02	prepare electrode flushing holes to provide adequate fluid flow
B-10.01.03	set up flushing nozzles to provide adequate fluid flow
B-10.01.04	ensure correct flushing during operation to prevent arcing

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Sub-task

B-10.02 **Sets cutting conditions.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

B-10.02.01	select electrode material such as graphite and copper
B-10.02.02	select electrode or wire size according to workpiece requirements
B-10.02.03	select power setting according to electrode material
B-10.02.04	monitor control panel for information such as voltage and amperage
B-10.02.05	maintain cutting conditions during operation to optimize cutting action

BLOCK C PROTOTYPES

Context

The purpose of building a prototype is to demonstrate the targeted characteristics of a finished product to the client. Tool and die makers develop prototypes prior to the production tooling or part development. They inspect and evaluate prototype function to ensure design criteria are met and manufacturability is confirmed and tested.

Trends

Rapid prototyping is quickly becoming a common process within the industry. Rapid prototyping is a method of prototyping with polymers or metal materials which takes only a few hours, compared to other prototyping processes which can take a few weeks.

Nanotechnology is more often being applied in the development of new materials to make them stronger and to optimize their durability.

Related Components

All components apply.

Tools and Equipment

See Appendix A.

Task 11 Develops prototype.

Required Knowledge

K 1	types of alignment tools such as indicators, sine bars and gauge blocks
K 2	types of clamps
K 3	work holding devices such as vises and V-blocks
K 4	types of fasteners such as screws and rivets
K 5	types of adhesives such as temporary and permanent
K 6	types of solder such as hard and soft
K 7	types of fits such as interference and running clearance
K 8	types of joints such as lap and dovetail
K 9	material characteristics such as hardness and weight
K 10	types of materials such as composites, woods and metals
K 11	fabrication methods such as electronic modeling, hand forming, machining and rapid prototyping

Sub-task

C-11.01 **Selects prototyping technique and materials.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

C-11.01.01 determine materials by matching prototype application with material characteristics according to resource availability

C-11.01.02 choose fabrication method such as electronic modeling, hand forming, machining and rapid prototyping according to job requirements and resource availability

C-11.01.03 determine fastening and joining techniques such as adhesive bonding, soldering, welding and mechanical fastening

Sub-task

C-11.02 **Fabricates prototype components.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

C-11.02.01 apply chosen fabrication method such as electronic modeling, hand forming, machining and rapid prototyping

C-11.02.02 draw sketches of prototype and component layout showing views of part relationships and assemblies

C-11.02.03 prepare components for any special treatment such as heat treating and coating according to client requirements

C-11.02.04 prepare components for assembly with hand finishing techniques such as filing, polishing and honing

C-11.02.05 inspect components to ensure conformance to sketches and drawings

Sub-task

C-11.03 Assembles prototype components.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

C-11.03.01	select and use tools and equipment such as clamps, indicators, wrenches, welding equipment and presses
C-11.03.02	set up components in relation to each other according to prototype sketches and drawings
C-11.03.03	develop special tooling aids such as clamps and fasteners
C-11.03.04	attach components to each other by fastening, welding and bonding

Task 12 Proves out prototypes.

Required Knowledge

K 1	types and uses of measuring equipment
K 2	principles of metrology
K 3	dimensional specifications such as clearances and tolerances
K 4	prototype specifications such as written instructions, electronic drawings, photographs and sketches
K 5	prototype application
K 6	types of physical tests such as motion, load and fatigue
K 7	industry standards such as International Standards Organization (ISO), ANSI and CSA
K 8	associated systems such as pneumatic, electric and hydraulic

Sub-task

C-12.01 **Inspects prototype.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

C-12.01.01	select and use measurement equipment such as vernier calipers, indicators and CMM to confirm physical and geometric specifications
C-12.01.02	perform visual inspection to confirm appearance according to client requirements
C-12.01.03	verify components' movements and interactions to ensure no interferences
C-12.01.04	ensure completeness of prototype prior to final evaluation
C-12.01.05	prepare quality assurance documentation to meet performance standards and traceability

Sub-task

C-12.02 **Evaluates function of prototype.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

C-12.02.01	prepare prototype for evaluation by making it ready for operations such as mounting on a press, and installing pneumatic, electric and hydraulic systems
C-12.02.02	try out prototype functions to ensure specifications are met
C-12.02.03	diagnose malfunctions of prototype by means such as visual inspection, measurement and documentation to isolate the problem

Sub-task

C-12.03 Resolves malfunction of prototype.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

C-12.03.01	fix identified problems by disassembling, modifying and repairing affected components
C-12.03.02	confirm functionality of altered prototype by repeating evaluation procedures

BLOCK D HEAT TREATMENT

Context

Tool and die makers must have knowledge of heat treating required to change the properties of materials. The processes are used to harden, improve machineability and reduce internal stress. Tool and die makers must be able to perform simple heat treating operations such as torch hardening, quenching and tempering of steels.

Tool and die makers must be able to test heat treated materials to determine specific characteristics. This is imperative to verify the condition of the material.

Trends

New surface treatments driven by increased durability requirements are now available on the market. These treatments such as hard chrome and titanium nitride coatings enhance the surface performance of production tools and influence the need for heat treatment.

Companies are also specializing in the heat treatment of new steels and application of coatings. This results in some heat treatment processes no longer being performed in tool shops.

Related Components

All components apply.

Tools and Equipment

Heat treating equipment, measuring tools, PPE and safety equipment.

Task 13 Heat treats materials.

Required Knowledge

K 1	types of heating mediums such as gas, electric and vacuum furnaces, and gas torches
K 2	composition of material
K 3	effect of heat on the properties of materials
K 4	quenching media and procedures
K 5	heat treatment procedures and outcomes
K 6	heat treatment specifications

K 7	heat treatment materials and equipment
K 8	metal cleaning processes

Sub-task

D-13.01 Selects heat treating process.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

D-13.01.01	identify heat treating procedure and equipment based on material application and characteristics according to part specifications and requirements
D-13.01.02	verify suitability and availability of heat treatment equipment to confirm feasibility of chosen procedure

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Sub-task

D-13.02 Hardens materials.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

D-13.02.01	set furnace cycle or torch settings according to material specifications
D-13.02.02	ensure part is prepared and cleaned
D-13.02.03	check quenching media temperature using tools such as thermometers and infrared scopes to ensure it is at room temperature or cooler
D-13.02.04	move quenching media to proximity of furnace if required to reduce heat loss of part
D-13.02.05	submerge and agitate part in quenching media to achieve hardness
D-13.02.06	remove part from quenching media when suitable temperature is attained
D-13.02.07	clean part to remove oil and scale using methods such as polishing, sandblasting, ultrasonic cleaning and de-scaling

Sub-task

D-13.03 Tempers materials.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

D-13.03.01	set furnace cycle or torch settings according to material specifications
D-13.03.02	ensure part is prepared and cleaned
D-13.03.03	ensure part is heated to set temperature according to tempering specifications to reach specified condition
D-13.03.04	confirm specified temperature is reached using equipment such as temperature sticks and colouring charts as required

Sub-task

D-13.04 Anneals materials.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

D-13.04.01	set furnace cycle according to material specifications
D-13.04.02	clean part to remove oil prior to heating process
D-13.04.03	ensure part is heated to set temperature according to annealing specifications to reach specified condition
D-13.04.04	control cool down rate according to material requirements following the annealing procedures

Sub-task

D-13.05 Normalizes materials.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

D-13.05.01	set furnace cycle according to material specifications
D-13.05.02	clean part to remove oil prior to heating process
D-13.05.03	ensure part is heated to set temperature according to normalizing specifications to reach specified condition
D-13.05.04	control cool down rate according to material requirements following the normalizing procedures

Sub-task

D-13.06 Carburizes materials.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	no	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

D-13.06.01	set furnace cycle or torch settings according to material specifications
D-13.06.02	ensure part is prepared and cleaned
D-13.06.03	ensure part is heated to set temperature according to case hardening specifications to reach specified condition
D-13.06.04	place part into carburizing material such as carbon powder to completely cover the part
D-13.06.05	check quenching media temperature using tools such as thermometers and infrared scopes to ensure it is at room temperature or cooler
D-13.06.06	move quenching media to proximity of furnace if required to reduce heat loss of part
D-13.06.07	submerge and agitate part in quenching media to achieve hardness
D-13.06.08	remove part from quenching media when suitable temperature is attained
D-13.06.09	clean part to remove oil and scale using methods such as polishing, sandblasting, ultrasonic cleaning and de-scaling

Task 14 Tests heat treated materials.

Required Knowledge

K 1	hardness testers such as Rockwell and Brinell
K 2	visual testing materials such as dye penetrant and magnifiers
K 3	hardness scales, quality conditions and specifications

Sub-task

D-14.01 Performs visual inspection.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

D-14.01.01	select and use tools and equipment such as magnifiers, dye penetrant and microscopes
D-14.01.02	prepare workpiece surface by cleaning and removing oxidization
D-14.01.03	identify surface imperfections such as scratches, cracks and craters
D-14.01.04	identify geometric deformations and distortions

Sub-task

D-14.02 Performs hardness test.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

D-14.02.01	select and use tools and equipment such as hardness testers, charts, indenters and V-blocks
D-14.02.02	prepare workpiece surface by cleaning and removing oxidization
D-14.02.03	verify hardness tester is functioning properly by using standard calibration samples
D-14.02.04	set up workpiece on hardness tester by aligning with indenter
D-14.02.05	activate mechanisms to initiate hardness test

D-14.02.06	read test value displayed and compare with specifications
D-14.02.07	record values for quality assurance

BLOCK E PRODUCTION TOOL DESIGN AND DEVELOPMENT

Context

Tool and die makers must be able to build production tools for the production and assembly of precision engineered products. Some tool and die makers may work in basic design of production tools.

Tool and die makers have to ensure that production tools maintain required accuracy. It is essential that they recognize the need for repair and maintenance of these tools.

New and reconditioned production tools must be proved out before being put into service. This ensures their safety, functionality and accuracy.

In some jurisdictions, tool and die makers may also be involved in building, repairing and maintaining moulds and automation tooling.

Trends

New materials and advanced coatings have been introduced. There is more high speed machining of hardened material for production tool manufacturing.

Related Components

Production tooling: jigs, fixtures, dies, moulds, cutting tools, stamping tools, automation tools.

Tools and Equipment

See Appendix A.

Task 15 Performs basic production tool design.

Required Knowledge

K 1	types of production tools such as dies, jigs, fixtures, cutting tools and moulds
K 2	limitations and capacity of shop equipment
K 3	functionality, limitations and applications of various types of tooling
K 4	strategies for supporting and retaining the part such as clamping, locating and repeatability
K 5	ergonomic principles and safe operation of production tool
K 6	types and availability of materials used in production tools
K 7	material properties of the production part

K 8	fool-proofing strategies in design
K 9	basic drafting techniques such as first and third angle projection, isometric drawing, and GDT
K 10	financial considerations of design in order to maintain cost-effectiveness
K 11	machining, forming and inspection techniques

Sub-task

E-15.01 Identifies production tool requirements.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-15.01.01	determine type of tooling required to perform the task according to part specifications
E-15.01.02	evaluate customer's production requirements such as volume and precision
E-15.01.03	determine tool capability such as rigidity, accuracy, and repeatability according to industry standards and reference material

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Sub-task

E-15.02 Prepares shop sketches.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-15.02.01	conceptualize design according to finished part requirements
E-15.02.02	use required sketching resources such as sketching paper and pencils, and measuring tools
E-15.02.03	apply sketching techniques which show all relevant features and dimensions as required for the design of the finished tool

Sub-task

E-15.03 **Determines production tool material specifications and engineered components.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-15.03.01	choose tooling component material types according to functional requirements
E-15.03.02	determine processes that will be required for finished tooling components such as surface treatments and heat treating
E-15.03.03	determine availability of engineered components and assess feasibility of use according to production schedule and cost-effectiveness
E-15.03.04	select engineered components based on job requirements and component availability

Sub-task

E-15.04 **Prepares information for drafting.**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-15.04.01	finalize production tool design including final dimensions and tolerances
E-15.04.02	list engineered components by supplier and part number for drawing specifications and purchasing requirements
E-15.04.03	list raw materials required for production tool components for drawing specifications and purchasing requirements
E-15.04.04	communicate with drafting department in order to clarify requirements and provide context

Task 16 Fits and assembles production tools.

Required Knowledge

K 1	types of production tools such as jigs, fixtures, dies, cutting tools and moulds
K 2	specifications for standard assembly fits and clearances
K 3	production tool specifications such as cutting clearances and draft angles as determined by material used
K 4	types of fasteners such as screws and dowels
K 5	types of adhesives such as temporary and permanent
K 6	types of solder such as hard and soft
K 7	types of fits such as interference and running clearance
K 8	types of joints such as lap and dovetail
K 9	types of dies such as cutting, forming, progressive and compound
K 10	types of jigs and fixtures such as drill jig, weld jig and assembly fixture
K 11	types of moulds such as injection, blow and rotary
K 12	clearance-setting practices such as inserting material between working faces and using light source
K 13	material properties such as composition and thickness
K 14	types of gauging material such as plastic and metal
K 15	types of compression aids such as springs, compressed gas cylinders and urethane
K 16	types of non-compression devices such as punch retainers, pilots, punches and buttons
K 17	pre-loads on die springs, compressed gas cylinders and urethane strippers
K 18	types of mechanisms such as cams, stock lifters and slide blocks
K 19	optimal sequence of operations for fitting and assembly

Sub-task

E-16.01 Verifies dimensions of production tool components.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-16.01.01	select measuring instruments based on tolerances required and application such as internal and external measurements
E-16.01.02	take measurements using standard and specialized measuring instruments
E-16.01.03	compare measurements to drawings and sketches to ensure conformity, fits and clearances
E-16.01.04	record critical dimensions as required by workplace procedures

Sub-task

E-16.02 Positions production tool components.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-16.02.01	kit production tool components and engineered components in organized manner, in order to facilitate assembly and ensure all required parts are present
E-16.02.02	develop special tooling aids such as clamps and fasteners
E-16.02.03	install required engineered products according to drawing or sketch
E-16.02.04	fasten production tool components temporarily as required to permit adjustments for alignment and fit
E-16.02.05	make necessary adjustments for fit, clearance and function according to specifications
E-16.02.06	fasten or clamp production tool components temporarily as required for final assembly

Sub-task

E-16.03 Performs final assembly.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-16.03.01	drill, tap and ream locating holes as required to permanently locate components
E-16.03.02	fasten components permanently using methods such as using engineered fasteners, applying adhesives, soldering and brazing
E-16.03.03	verify final dimensions and fit to ensure functioning of production tool

Sub-task

E-16.04 Sets production tool timing.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-16.04.01	adjust final height of cutting punches to achieve required punch penetration
E-16.04.02	adjust final height of forming punches to achieve required form of the part
E-16.04.03	adjust cam engagement of stamping dies to achieve required lateral punch penetration or form
E-16.04.04	adjust cam engagement of moulds to achieve required seal
E-16.04.05	adjust stripper plates, ejectors, compression springs and shut-height to achieve required functioning of the tool

Task 17 Proves out production tools.

Required Knowledge

K 1	safety considerations for operating production equipment
K 2	types of presses such as punch press, brake press and hydraulic press and their operation
K 3	types of moulding equipment and their operation
K 4	types of machine tools and their operation
K 5	production part material specifications such as composition, thickness, hardness, ductility and malleability
K 6	material classifications such as ANSI, SAE and Universal Numbering System (UNS)
K 7	production part geometry according to specifications
K 8	types of dies, jigs and fixtures such as draw dies, form dies, trim dies, checking fixtures, assembly fixtures and drill jigs
K 9	strip layout, stock progression and feed mechanism
K 10	production tool's intended function and operation such as volume of production part and consistency in quality
K 11	critical areas to check for damage
K 12	stock handling equipment such as coil feeders, cradles, bar feeds, straighteners and material hoppers

Sub-task

E-17.01 Sets up production tools.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-17.01.01	determine equipment required for operation of production tool
E-17.01.02	install, align and secure production tool to equipment according to type of tool
E-17.01.03	connect press accessory systems such as stock feeders, hydraulic lines and pneumatic clamps
E-17.01.04	connect mould accessory systems such as water lines, misters, parts catchers and conveyor systems

Sub-task

E-17.02 Verifies production part material.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-17.02.01	ensure that material conforms with the design specifications
E-17.02.02	interpret material identification such as conformance documents, trace identification tags and markings on the material
E-17.02.03	identify materials by physical properties
E-17.02.04	ensure that feed stock is free from damage, foreign matter or other contamination that may impact final product quality or damage the tool

Sub-task

E-17.03 Develops blank.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-17.03.01	calculate amount of material required for finished shape by using applicable tables and formulas
E-17.03.02	select press and settings required according to material and product
E-17.03.03	perform circle grid analysis to assess inconsistent material flow
E-17.03.04	develop draw radius and adjust clamping force on the blank using draw beads to achieve uniform material thickness
E-17.03.05	evaluate material changes such as thinning, thickening, folding and flow in order to maintain dimensions to specifications
E-17.03.06	verify profile geometry against customer-supplied specifications using CMM
E-17.03.07	record final blank dimensions to manufacture production blanks

Sub-task

E-17.04 Cycles equipment with production tools.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-17.04.01	check clearances and interferences between equipment, production tool and workpiece
E-17.04.02	operate machine tool at reduced rate if required to verify function and minimize risk of damage to equipment and production part
E-17.04.03	verify and adjust timing as required to optimize tool performance
E-17.04.04	perform adjustments to die components such as stripper plate and die springs
E-17.04.05	perform adjustments to accessories such as feeders, coils and straighteners
E-17.04.06	perform press adjustments such as shut height, pressure pads, limit switches and counterbalance
E-17.04.07	assess production at normal conditions to ensure that part volume and consistency are optimal and to observe trends in production

Sub-task

E-17.05 Evaluates production part.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-17.05.01	examine part visually for deficiencies such as poor surface finish, burrs and part damage
E-17.05.02	measure part dimensions to confirm that measurements conform to specifications
E-17.05.03	document the results of the evaluation including data such as critical dimensions, surface finish and tolerances

Sub-task

E-17.06 Checks production tool for damage.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-17.06.01 visually inspect tools for damage such as cracks, breaks and deformities

E-17.06.02 use optical aids such as loupe eyeglasses and magnifiers

Sub-task

E-17.07 Modifies production tools to enhance productivity.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-17.07.01 adjust mechanisms such as stock feeders and limit switches

E-17.07.02 recommend surface treatment coatings such as nitride, plating or anodizing to enhance the productivity and wear resistance of production tool

E-17.07.03 streamline load and unload processes to reduce cycle time

E-17.07.04 change tool materials to optimize tool life and cycle time

Task 18 Repairs and maintains production tools.

Required Knowledge

K 1 application, function and original specifications of production tools such as jigs, fixtures, dies and moulds

K 2 production tool component properties such as material type, hardness and surface finish

K 3 production part specifications such as material types, properties, finish and dimensions

K 4 types of production tool defects such as worn bushings, broken clamps and worn surfaces

K 5	methods and sequence of production tool assembly/disassembly
K 6	types of engineered components such as bushings, hinges, screws and dowels
K 7	types of accessories such as hydraulic and pneumatic
K 8	types of production tool mechanisms such as cams, strippers and stock pushers
K 9	cleaning agents such as solvents and degreasers
K 10	cleaning tools, techniques and procedures
K 11	types of production part defects such as burrs, cracks, flash and dimensional non-conformities
K 12	repair procedures such as disassembling, resurfacing, polishing, adjusting timing of die mechanisms and sharpening
K 13	machine tools and hand tools used to recondition faulty components
K 14	current production values such as batch sizes and sharpening cycle

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Sub-task

E-18.01 Identifies condition of production tools.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-18.01.01	monitor and evaluate production part for non-conformance to specifications
E-18.01.02	observe operation of production tool to evaluate need for repair, adjustment or reconditioning
E-18.01.03	compare condition of production tools to original specifications using measuring instruments such as vernier calipers and micrometers
E-18.01.04	record production tool defects according to company policies and procedures

Sub-task

E-18.02 Identifies repair procedures.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-18.02.01	analyze information recorded during part and tool evaluation
E-18.02.02	decide on and develop a repair procedure based on defect and tool type
E-18.02.03	use reference materials to determine possible repair procedures

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Sub-task

E-18.03 Adjusts production tool components.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-18.03.01	perform adjustments to jigs and fixtures such as shimming, realigning, levelling and relocating stops
E-18.03.02	perform adjustments to dies such as shimming, peening and realigning
E-18.03.03	perform adjustments to moulds such as shimming and realigning
E-18.03.04	verify that production part conforms to specifications
E-18.03.05	record production tool adjustments according to company policies and procedures

Sub-task

E-18.04 Reconditions production tool components.

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
NV	yes	yes	NV	yes	yes	yes	ND	NV	yes	ND	ND	ND

Key Competencies

E-18.04.01	remove residues such as grease, dirt and oil from component surfaces
E-18.04.02	remove excess production part material using equipment such as abrasive stones and polishing media
E-18.04.03	determine reconditioning methods such as machining, applying surface treatments and replacing components
E-18.04.04	repair components by machining or applying surface treatments
E-18.04.05	fabricate new components for production tools when components are damaged beyond repair
E-18.04.06	replace engineered components for production tools as required
E-18.04.07	inspect reconditioned component to confirm completeness of repair
E-18.04.08	record production tool reconditioning according to company policies and procedures

APPENDICES

APPENDIX A TOOLS AND EQUIPMENT

Safety Equipment

dust mask
eye wash station
fire blanket
fire extinguishers
fire hoses
first aid station
goggles/safety glasses/face shield
hand protection
hearing protectors
protective clothing
protective head gear
respirators
safety barrier tapes
safety boots

Hand Tools

abrasive stones
Allen keys
bearing extractor
brushes
chisels
chuck key
clamp
deburrers
dressing stick
drill drift
drill gauge
file cards
file handles
files
grease guns
hacksaws and blades
hammers/mallets
hand reamers
honing stones
lapping plate
layout dye
loupe eyeglass
magnifying screens and glasses
metal stamps
oil cans/guns
pliers
punches and bars
rasps
scrapers
screwdrivers
soft jaws
spotting blue
tap extractors
tap wrenches
temperature sticks
tin snips
torch tip lighters
wheel dressers (hand held)
wrenches

Power Tools

air grinder
bench grinder
die grinder
disc grinder
drill press
portable drill
power saws

Machine Tools

abrasive cut-off saw
band saw
computer numerical control (CNC)
die spotting press
drilling machines
Electrical Discharge Machine (EDM)
grinders
hydraulic/mechanical press
jig borer
lathe
machine tools
milling machines

Cutting Tools

abrasive wheels
boring bars
boring heads
broaches
counterbore
countersink
drill bits
EDM electrodes
grinding wheels
knurling tools
milling cutters
parting-off tools
reamers
saw blades
spot facers
taps and die
turning tools

Layout Equipment

combination set
dividers and trammels
etchers
hermaphrodite calipers
layout dye
layout table
punches
scribers
squares
surface gauges
surface plates / surface tables
vernier height gauge

Measuring and Testing Tools

angle gauge blocks
angle plate
bore gauge
calipers
combination square
coordinate measuring machine (CMM)
deflection tester
depth gauge
dial indicators
die maker square
electronic measuring devices
feeler gauge
gauge blocks
hardness tester
height micrometer
measuring rods
measuring tape
micrometers
non-destructive testing equipment
optical comparator
optical flats
precision blocks
precision level
protractor
radius gauge
refractometer

Measuring and Testing Tools (continued)

sine bar (compound)
sine plate (compound)
small hole gauge
squares
steel rules
surface finish comparator
surface plate
telescopic gauge
temperature block
tensile strength tester
thread gauge
thread measuring wires
tooling ball
trammel
vernier caliper
vernier height gauge
vernier protractor

Heat Treating Equipment

furnaces
ladles
quenching mediums
stainless steel wrap
tongs
torches

Accessories and Work Holding Devices

adaptors
angle plates
arbour press
arbours
centre and edge finders
centres
chucks
clamps
collets
crane
degreasing tanks
die light
dividing head
drill chuck
drive dogs
drive plate
faceplates
follower/travelling rest
forklift
grinding attachment
grinding wheel balancers
grinding wheel dressers
hoists
indexing heads
jacks
laptop or personal computer (PC)
lathe centres
lathe dogs
machine vise
mandrels
parallels
precision stops
quick change toolpost
rotary grinding attachments
rotary table
shim stock
slings
spacers
steady rest
tail stock
taper sleeves
taper turning attachment
tapping head
tool holders
trip dogs
turret toolpost
V-block
vises

APPENDIX B GLOSSARY

anneal	softening hardened steel through the heat treating process
boring	a machining process that produces a cylindrical or conical hole using a single point tool
Brinell	a scale for measuring hardness
carburize	the process of impregnating the surface of steel with carbon
computer numerical control (CNC)	the control of a machine tool using coded instructions
die	a device for cutting or forming material to produce a finished product; see **production tools**
drill press	a machine used to produce holes in workpieces; reaming, tapping, spotfacing and countersinking can also be performed on drill presses
fixture	a work holding device to position a workpiece; see **production tools**
G code	preparatory command
grinder	a machine that removes material from workpieces using abrasive wheels
heat treatment	the heating and cooling of metals to modify their mechanical properties
jig	a device that holds a piece in position to guide a cutting tool; see **production tools**
knurling	using a tool to produce a pattern on the diameter of a workpiece in a lathe
lathe	a machine-tool that holds and rotates the workpiece; a cutting tool is moved on slideways to cut cylindrical, tapered or threaded features on a workpiece
M Code	miscellaneous function command
machine-tool	a stationary, usually heavy and non-portable, power-driven machine used to cut, shape, or form metals
Machinery's Handbook	a reference book used in manufacturing by professionals such as engineers, toolmakers and machinists

milling machine	a machine that cuts surfaces and contours by holding the workpiece against a rotating cutter with single or multiple cutting edges
mould	device used to form parts by injection or vacuum process; see **production tools**
normalize	removing internal stress from the metal
production tools	types of custom made specialty devices used in the production of quantities of components by repetitive manufacturing operations. They may perform operations such as cutting, forming or moulding of individual components, they may be tools which align and hold parts for secondary operations and assembly or they may be measuring tools used to qualify final parts during inspection. A few examples are metal stamping dies, plastic injection moulds, assembly fixtures, drill jigs, templates and gauges
prototype	a test product manufactured with non-production tools to assist in the development of an end product
proving out	procedure to test out prototypes, jigs, fixtures and dies for function
quench	cooling heated material at a pre-determined rate to set the material hardness
S Code	spindle speed control
saw	a machine used to cut materials using a multi-tooth blade
spotface	a flat surface at 90° to a hole
tapping	cutting threads within a hole using a cutting tool called a tap
temper	a method of changing the hardness of steel parts by first heating to a low temperature then cooling; tempering improves toughness
tooling	generally refers to the collection of production tools used within a manufacturing facility for their particular processes; see **production tools**

APPENDIX C ACRONYMS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineering
CAD	computer-aided design
CAM	computer-aided manufacturing
CBN	cubic boron nitride
CMM	coordinate measuring machine
CNC	computer numerical control
CSA	Canadian Standards Association
EDM	Electrical Discharge Machine
GDT	geometric dimensioning and tolerancing
HSS	high speed steel
ISO	International Standards Organization
MILSPEC	military specifications
MSDS	Material Safety Data Sheet
NPS	National Pipe Straight
NPT	National Pipe Taper
OH&S	Occupational Health and Safety
PC	personal computer
PLC	programmable logic controller
PPE	personal protective equipment
SAE	Society of Automotive Engineers
UNC	Unified National Coarse (a thread system for coarse threads)
UNF	Unified National Fine (a thread system for fine threads)
UNS	Universal Numbering System
WHMIS	Workplace Hazardous Materials Information System

APPENDIX D BLOCK AND TASK WEIGHTING

BLOCK A COMMON OCCUPATIONAL SKILLS

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	National Average
%	NV	15	8	NV	20	15	20	ND	NV	15	ND	ND	ND	16%

Task 1 Performs safety-related functions.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	15	10	NV	10	7	25	ND	NV	30	ND	ND	ND	16%

Task 2 Uses and maintains machine-tools and tooling.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	35	10	NV	20	20	25	ND	NV	30	ND	ND	ND	23%

Task 3 Organizes work.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	25	30	NV	40	26	25	ND	NV	20	ND	ND	ND	28%

Task 4 Performs benchwork.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	25	50	NV	30	47	25	ND	NV	20	ND	ND	ND	33%

BLOCK B MACHINE-TOOL SETUP AND OPERATION

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	National Average
%	NV	35	10	NV	20	20	20	ND	NV	30	ND	ND	ND	22%

Task 5 Plans and prepares for machine-tool operations.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	20	30	NV	25	25	20	ND	NV	10	ND	ND	ND	22%

Task 6 Operates conventional drill presses, lathes and milling machines.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	33	15	NV	40	40	20	ND	NV	30	ND	ND	ND	29%

Task 7 Operates power saws.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	5	5	NV	5	5	20	ND	NV	10	ND	ND	ND	8%

Task 8 Operates grinders.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	14	10	NV	15	15	20	ND	NV	20	ND	ND	ND	16%

Task 9 Operates computer numerical control (CNC) machines.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	14	20	NV	10	10	10	ND	NV	20	ND	ND	ND	14%

Task 10 Operates Electrical Discharge Machines (EDM).

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	14	20	NV	5	5	10	ND	NV	10	ND	ND	ND	11%

BLOCK C PROTOTYPES

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	National Average
%	NV	5	22	NV	15	10	20	ND	NV	10	ND	ND	ND	14%

Task 11 Develops prototype.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	60	75	NV	50	60	40	ND	NV	70	ND	ND	ND	59%

Task 12 Proves out prototypes.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	40	25	NV	50	40	60	ND	NV	30	ND	ND	ND	41%

BLOCK D HEAT TREATMENT

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	National Average
%	NV	10	10	NV	5	5	20	ND	NV	5	ND	ND	ND	9%

Task 13 Heat treats materials.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	70	85	NV	70	90	40	ND	NV	70	ND	ND	ND	71%

Task 14 Tests heat treated materials.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	30	15	NV	30	10	60	ND	NV	30	ND	ND	ND	29%

BLOCK E PRODUCTION TOOL DESIGN AND DEVELOPMENT

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	National Average
%	NV	35	50	NV	40	50	20	ND	NV	40	ND	ND	ND	39%

Task 15 Performs basic production tool design.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	15	25	NV	50	10	25	ND	NV	30	ND	ND	ND	26%

Task 16 Fits and assembles production tools.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	35	20	NV	20	40	25	ND	NV	30	ND	ND	ND	28%

Task 17 Proves out production tools.

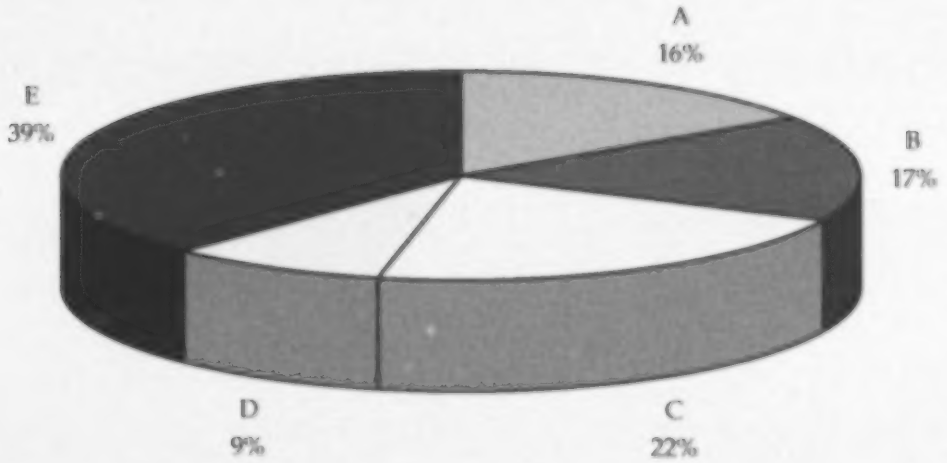
	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	NV	25	25	NV	20	10	25	ND	NV	20	ND	ND	ND	21%

Task 18 Repairs and maintains production tools.

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU	
%	22	25	30	NV	10	40	25	ND	NV	20	ND	ND	ND	25%

APPENDIX E

PIE CHART*



TITLES OF BLOCKS

BLOCK A	Common Occupational Skills	BLOCK D	Heat Treatment
BLOCK B	Machine-tool Setup and Operation	BLOCK E	Production Tool Design and Development
BLOCK C	Prototypes		

*Average percentage of the total number of questions on an interprovincial examination, assigned to assess each block of the analysis, as derived from the collective input from workers within the occupation from all areas of Canada. Interprovincial examinations typically have from 100 to 150 multiple-choice questions.

APPENDIX F

TASK PROFILE CHART – Tool and Die Maker

BLOCKS	TASKS	SUB-TASKS				
A – COMMON OCCUPATIONAL SKILLS	1. Performs safety-related functions.	1.01 Maintains safe work environment.	1.02 Uses personal protective equipment (PPE) and safety equipment.			
	2. Uses and maintains machine-tools and tooling.	2.01 Uses hoisting and lifting equipment.	2.02 Maintains machine-tools and tooling.			
	3. Organizes work.	3.01 Interprets drawings, specifications and applications.	3.02 Plans project activities.			
	4. Performs benchwork.	4.01 Performs layout.	4.02 Marks material for identification.	4.03 Inspects workpiece.	4.04 Finishes workpiece.	
B – MACHINE-TOOL SETUP AND OPERATION	5. Plans and prepares for machine-tool operations.	5.01 Plans machining sequence.	5.02 Establishes workpiece datum.	5.03 Sets up work holding devices in machine-tools.	5.04 Sets up machine tooling and accessories.	5.05 Sets up workpiece in machine-tool.
		5.06 Selects speeds and feeds of machine-tools.				

BLOCKS	TASKS	SUB-TASKS				
	6. Operates conventional drill presses, lathes and milling machines.	6.01 Performs hole making and finishing operations.	6.02 Turns surfaces using lathe.	6.03 Faces surfaces using milling machine.	6.04 Performs parting, grooving and knurling using lathe.	6.05 Cuts internal and external threads using lathe.
		6.06 Performs profiling, pocketing and slotting using milling machine.				
	7. Operates power saws.	7.01 Saws straight and angle cuts.	7.02 Cuts irregular shapes.			
	8. Operates grinders.	8.01 Mounts grinding wheel.	8.02 Grinds flat surfaces.	8.03 Grinds profiles and tapered surfaces.		
	9. Operates computer numerical control (CNC) machines.	9.01 Performs basic CNC programming.	9.02 Inputs program data into control memory.	9.03 Sets up workpiece datum.	9.04 Verifies programs.	9.05 Monitors machining processes.
	10. Operates Electrical Discharge Machines (EDM).	10.01 Determines flushing methods.	10.02 Sets cutting conditions.			
C – PROTOTYPES	11. Develops prototype.	11.01 Selects prototyping technique and materials.	11.02 Fabricates prototype components.	11.03 Assembles prototype components.		
	12. Proves out prototypes.	12.01 Inspects prototype.	12.02 Evaluates function of prototype.	12.03 Resolves malfunction of prototype.		

BLOCKS	TASKS	SUB-TASKS				
D – HEAT TREATMENT	13. Heat treats materials.	13.01 Selects heat treating process.	13.02 Hardens materials.	13.03 Tempers materials.	13.04 Anneals materials.	13.05 Normalizes materials.
		13.06 Carburizes materials.				
	14. Tests heat treated materials.	14.01 Performs visual inspection.	14.02 Performs hardness test.			
E – PRODUCTION TOOL DESIGN AND DEVELOPMENT	15. Performs basic production tool design.	15.01 Identifies production tool requirements.	15.02 Prepares shop sketches.	15.03 Determines production tool material specifications and engineered components.	15.04 Prepares information for drafting.	
	16. Fits and assembles production tools.	16.01 Verifies dimensions of production tool components.	16.02 Positions production tool components.	16.03 Performs final assembly.	16.04 Sets production tool timing.	
	17. Proves out production tools.	17.01 Sets up production tools.	17.02 Verifies production part material.	17.03 Develops blank.	17.04 Cycles equipment with production tools.	17.05 Evaluates production part.
		17.06 Checks production tool for damage.	17.07 Modifies production tools to enhance productivity.			
	18. Repairs and maintains production tools.	18.01 Identifies condition of production tools.	18.02 Identifies repair procedures.	18.03 Adjusts production tool components.	18.04 Reconditions production tool components.	